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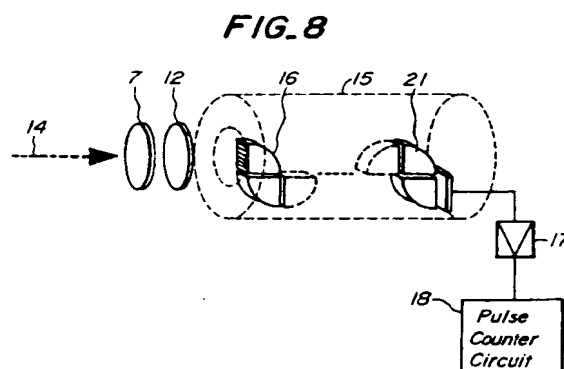
⑦① Applicant : **HIROSHIMA UNIVERSITY**  
**1-89, Higashisenda-machi 1-chome**  
**Naka-ku**  
**Hiroshima City Hiroshima Pref. (JP)**

⑦② Inventor : **Namatame, Hirofumi**  
**7-13-41 Saijo-Chuo**  
**Higashihiroshima City, Hiroshima Pref (JP)**  
Inventor : **Taniguchi, Masaki**  
**14-14-302 Kuchida 3-chome,**  
**Asakita-ku**  
**Hiroshima City, Hiroshima Pref (JP)**

⑦④ Representative : **Nicholls, Michael John et al**  
**J.A. KEMP & CO.**  
**14, South Square**  
**Gray's Inn**  
**London WC1R 5LX (GB)**

⑤④ **Passband-adjustable photo-detector for inverse photoemission spectroscopy.**

⑤⑦ A passband-adjustable photo-detector for inverse photoemission spectroscopy, in which an electron beam from an electron gun is applied onto a sample and a light reflected therefrom is converged, so as to effect photo-detection, wherein said photo-detector comprises a photo-electron multiplier, a LiF monocrystal window and a CaF<sub>2</sub> monocrystal window individually deposited with a KC<sub>2</sub> thin film in the front of a photo-electron multiplier in the photo-detector, wherein said windows means are provided for arbitrarily setting the temperature from the vicinity of liquid nitrogen temperature to the order of 150°C, a photo-electron multiplier having a first dynode deposited a KC<sub>2</sub> thin film on a surface thereof. The output of the photo electron multiplier is connected with a pulse counter circuit through an amplifier, so as to measure anyone selected from the group consisting of light absorption property, window transmissibility and sensitivity as a bandpass filter.



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The present invention relates to a passband-adjustable photo-detector for inverse photoemission spectroscopy, which belongs to technical fields of electron technology and photon technology and is used for a high resolution inverse photoemission spectroscopy.

A bandpass filter type photo-detector for inverse photoemission spectroscopy is formed of a simple combination of low-cut and high-cut filters. In a recently developed photo-detector having the most excellent property, as the low-cut filter, there is adopted a photoelectron multiplier which is provided with Cu-BeO deposited with  $KCl$  thin film on a surface thereof for the first dinode, while as the high-cut filter, there is adopted  $SrF_2$  monocrystal window, in which a sensitivity property of central energy 9.40 eV and half value width 0.47 eV as shown in Fig. 1 is employed.

This bandpass filter type photo-detector is featured in that the structure is simple and the operational stability is high. However, the obtainable resolution thereof is no more than 0.47 eV at most.

The photoemission spectroscopy and the inverse photoemission spectroscopy are means for directly observing occupied and unoccupied electronic states of energy in material, respectively, and they have a complementary relation with each other. The presently standardized resolution of the photoemission spectroscopy is in order of 0.3 eV. The investigation of occupied and unoccupied electronic states of energy with the precision of the same order under the employment of the photoemission and the inverse photoemission spectroscopies respectively is extremely desirable for the research of material. It is necessary for the realization thereof to narrow the bandwidth of the bandpass filter type photo-detector into the order of 0.3 eV.

In general, when the higher resolution is sought, the detection sensitivity is lowered in accompaniment therewith. The matter is the same as to the bandpass filter type photo-detector. In case that the surface of the material to be measured is unstable in vacuum, an experiment in which signals should be accumulated for a long time is unpracticable. In this case, it is required to raise the detection sensitivity at the sacrifice of the resolution. However, it is impossible to vary the passband of the conventional bandpass filter type photodetector during the experiment. Accordingly, for practising the high resolution it is necessary to provide a measuring apparatus comprising two kinds of detectors, that is, a high resolution detector, even if the detection sensitivity is somewhat low, and a high sensitivity detector.

Photoemission spectroscopy and inverse photoemission spectroscopy provide information relating to occupied and unoccupied electronic states respectively, so that the whole aspect of electronic states of the material cannot be clarified until both of these are combined. The resolution of the conventional photo-

emission spectroscopy is of the order of about 0.3 eV, while the resolution of the conventional inverse photoemission spectroscopy is of the order of about 0.5 eV. Accordingly, for comparing and investigating respective data of both of these spectroscopies it is necessary to afford comparable resolutions thereto. The inverse photoemission spectroscopy is a method for clarifying the unoccupied electronic state of the material by taking notice of a certain single energy component of light emitted from the surface of the sample to which is applied a monochromatized electron beam and by observing the intensity of the emitted light as a function of the energy of the electron beam. The energy width of the electron beam is defined by the expanse of thermoelectron in the electron source and hence about 0.25 eV. On the other hand, the width of pass band of the bandpass filter type photodetector is about 0.47 eV at the least conventionally and has been improved into 0.35 eV by recent technical development. However, for obtaining resolution comparable with that of the photoemission spectroscopy it is necessary to narrow the passband of the photodetector into the order of the electron beam width of 0.25 eV.

In general, when the resolution is raised, the detection sensitivity is lowered. It is the same in the bandpass filter type photodetector for inverse photoemission spectroscopy, so that, when the half value width of the detector is narrowed, the detection sensitivity is lowered and hence longer time is required for the measurement. On the other hand, when the half value width is widened, the sensitivity is raised and hence the measurement is carried out in short time. In general, whether the resolution or the sensitivity is preferential, is decided by the limitation of the time required for the measurement and whether the material to be measured is stable or not in super high vacuum wherein the inverse photoemission spectroscopy is effected.

#### Summary of the Invention

The present invention is the technology for continuously varying the resolution of the inverse photoemission spectroscopy from a higher value than the conventional one, that is, in the same order as that of usual photoemission spectroscopy or higher than it, to a lower value, so as to necessarily exhibit a mighty power in the practical high resolution experiment.

According to the present invention, it can be realized to select whether the aforesaid resolution or the sensitivity is preferential by electrically controlling the half value width of the bandpass filter without any change of the experimental apparatus during the experiment, so that it can be readily realized to remarkably save the time required for the experiment and further to respond to the measurement of the material which does not suit with a long time measurement by

raising the sensitivity at the partial sacrifice of the resolution, so as to exceedingly contribute to the research of material property.

The present invention relate to a passband-adjustable photo-detector for inverse photo emission spectroscopy, in which an electron beam from an electron gun is applied onto a sample and a light reflected therefrom is converged into a photo-electron multiplier, so as to effect photo-detection, said photo-detector comprising a photo-electron multiplier, a LiF monocrystal window, and a  $\text{CaF}_2$  monocrystal window respectively deposited with  $\text{KCl}$  thin film being provided in the front of a photo-electron multiplier, wherein said windows are provided for arbitrarily setting the temperature from the approximate of liquid nitrogen temperature to the order of  $150^\circ\text{C}$ , a first dinode deposited a  $\text{KCl}$  thin film on a surface of a first dinode of said photo-electron multiplier, wherein an output of said photo-electron multiplier is connected with a pulse counter circuit through an amplifier, so as to measure any one selected from the group consisting of light absorption property, the window transmissibility and the sensitivity as a bandpass filter for inverse photoemission spectroscopy.

The invention will be further described by way of example with reference to the accompanying drawings, in which:-

Fig. 1 is a diagram showing a property of a conventional bandpass filter type photo-detector for inverse photoemission spectroscopy, as mentioned before;

Fig. 2 is an outlined diagram showing the principle of a passband-adjustable photo-detector for inverse photoemission spectroscopy according to the present invention;

Fig. 3 is a diagram showing a principal arrangement of an embodiment of the photo-detector according to the present invention;

Fig. 4 is a diagram showing the energy dependency of transmissibility of the window in the photo-detector according to the present invention;

Fig. 5 is a diagram showing a light absorption property of a  $\text{KCl}$  thin film in the photo-detector according to the present invention;

Fig. 6 is a diagram showing a sensitivity property of a photo-electron multiplier deposited with a  $\text{KCl}$  thin film in the photo-detector according to the present invention;

Fig. 7 is a diagram showing a property of the bandpass filter in the bandwidth adjustable photo-detector according to the present invention;

Fig. 8 is a diagram showing a principal concrete arrangement of the photo-detector according to the present invention;

Fig. 9A and 9B are diagrams showing temperature dependency of absorption factor and transmission coefficient of photon energy at 74K, 273K and 275K respectively;

Fig. 10 is a diagram showing photoemission absorption property of  $\text{KCl}$  deposited thin film at 1000 Å, 1500 Å and 500 Å in the photo-detector according to the present invention;

Fig. 11 is a diagram showing a bandpass filter characteristic presenting asymmetric peak structure of the combination of a  $\text{CaF}_2$  monocrystal window and a  $\text{KCl}$  deposited first dinode of the photo-electron multiplier in the photo-detector according to the present invention;

Fig. 12 is a diagram showing transmission property of a LiF monocrystal window deposited with  $\text{KCl}$  thin film in the photo-detector according to the present invention;

Fig. 13 is a diagram showing transmission property of a LiF monocrystal window used for a substrate of a  $\text{KCl}$  deposited thin film in the photo-detector according to the present invention; and Fig. 14 is a diagram showing temperature dependency of a bandpass filter in the photo-detector according to the present invention.

Throughout different views of the drawings; 1 is an electron gun, 2 is an electron beam, 3 is a sample, 4 is a reflected light, 5 is a converging mirror, 6 is a photo-detector, 7 is a LiF monocrystal window deposited with  $\text{KCl}$  thin film, 8 is liquid nitrogen, 9 is a crystal, 10 is a thermo-couple, 11 is a heater, 12 is a  $\text{CaF}_2$  monocrystal window deposited with  $\text{KCl}$  thin film, 13 is a  $\text{KCl}$  thin film, 14 is a light, 15 is a photoelectron multiplier, and 16 is a first dinode.

#### Description of the Preferred Embodiment

The present invention is actually explained in detail with respect to the attached drawings.

Fig. 2 shows an outlined principle of an inverse photoemission spectroscope, in which 1 is an electron gun, 2 is an electron beam emitted therefrom, and 3 is a sample. The electron beam 2 emitted from the electron gun is applied on the sample 3. Light 4 emitted from the sample 3 is converged by a converging mirror 5, so as to irradiate a photo-detector 6.

Fig. 3 shows an outlined principle of a passband width-adjustable photo-detector for inverse photoemission spectroscopy according to the present invention. In Fig. 3, a principal structure of an inverse photoemission spectroscope comprised in the photo-detector as shown in Fig. 2 is illustrated. In Fig. 3, 7 is a LiF monocrystal window, on a surface of which a  $\text{KCl}$  thin film 13 is deposited with 100 Å thickness, and a LiF monocrystal window 7 is refrigerated at the vicinity of liquid nitrogen temperature individually through cryostats 9, which accommodate liquid nitrogen 8 and additionally comprise thermocouples 10 and heaters 11, so as to provide temperature adjusting arrangement.

$\text{CaF}_2$  monocrystal 12 is supported with cryostats 9 accommodated with a liquid nitrogen 8 as same as

in LiF monocrystal window and is attached a temperature regulated comprising with a thermo-couple 10 and a heater 11.

An incident light 14 shown in Fig. 3 is the same as an incident light projected into the photo-detector 6 as shown in Fig. 2, it is applied on a first dinode 16, on a surface of which a KCl thin film is deposited at 1000 Å thickness, of a photo-electron multiplier 15 of solar blind type (e.g. HTV:R-595), through the LiF monocrystal window 7 and the CaF<sub>2</sub> monocrystal window 12 refrigerated at the vicinity of liquid nitrogen temperature.

The incident light into the photo-detector 6 passes through two windows of a KCl thin film coated LiF monocrystal window 7 and a KCl thin film coated CaF<sub>2</sub> monocrystal window 12.

A cutoff energy of the LiF monocrystal window 7 is 12 eV at room temperature, while a cutoff energy of the CaF<sub>2</sub> monocrystal window 12 is 10 eV at room temperature. Consequently, as is apparent from the energy dependency of the transmission factor of these windows as shown in Fig. 4, the light having energy more than about 10 eV cannot pass through these windows.

As shown in Fig. 5, the KCl thin film has a light absorption property which presents mighty and sharp peaks approximately at 9.5 eV and 8.0 eV. This light absorption property is emphasized by refrigeration, and hence these peaks become further mighty and sharp. According to this effect, the same result as obtained by 150 Å thickness at room temperature can be obtained by about 100 Å thickness under the refrigeration. In addition, the light absorption of KCl thin film at the vicinity of 9.8 eV is somewhat reduced at very low temperature from that at room temperature, so that such a condition as light transmission is ready at the vicinity of 9.8 eV just before the cutoff energy of CaF<sub>2</sub> monocrystal window, while said condition at the vicinity of 9.5 eV is difficult can be obtained.

The incident light successively passing through LiF monocrystal window 7 and CaF<sub>2</sub> monocrystal window 12 is applied on the photo-electron multiplier 15 comprising the first dinode 16 of the photo-detector 6. The incident light is applied to the KCl thin film and the photoelectron is emitted from the surface of said thin film, and is amplified by the photo-electron multiplier 15. As shown in Fig. 6, the photoemission of KCl thin film of 1000 Å thick appears about at 8 eV and is suddenly increased at the vicinity of 9 eV. The combination of LiF monocrystal window 7 and CaF<sub>2</sub> monocrystal window 12 provides a high cut filter having a bandpass structure at the vicinity of the cutoff energy of CaF<sub>2</sub> monocrystal window of about 10 eV, while the combination of the photo-electron multiplier 15 and the first dinode 16 provides a low cut filter on the basis of high sensitivity in an energy range exceeding the vicinity of 9 eV.

Consequently, the combination of the photoelec-

tron multiplier 15, the first dinode 16, the LiF monocrystal window 7 and the CaF<sub>2</sub> monocrystal window 12 provides a bandpass property having a peak at 9.8 eV. The temperature of the CaF<sub>2</sub> monocrystal window can be varied from low temperature, that is, liquid nitrogen temperature to high temperature, that is, about 150°C, and further can be maintained at arbitrary temperature. The cutoff energy of CaF<sub>2</sub> monocrystal window 12 is about 10 eV at room temperature, and is shifted toward high energy side as the temperature is lowered, while toward low energy side as the temperature is raised. For instance, when the temperature is raised to 150°C, the cutoff energy is transferred to a low energy side of about 0.3 eV. The property on higher energy side of the bandpass filter type photoemission detector is defined by the cutoff property of CaF<sub>2</sub> monocrystal window 12, so that the bandwidth is varied by the temperature variation of the window 12. As shown in Fig. 7, the bandwidth of 0.35 eV at room temperature is narrowed into about 0.2 eV at 150°C. So that arbitrary bandwidth can be set in this temperature range.

(Embodiment)

An actual example of the passband adjustable photo-detector for inverse photoemission spectroscopy according to the present invention will be described hereinafter.

The construction of photo-detector is shown in Fig. 8. Fig. 8 shows an example of actual arrangement of the photo-detector 6 as shown in Fig. 2, in which 14 is the incident light, 7 is a LiF monocrystal window deposited with KCl thin film in 100 Å thick, 12 is a CaF<sub>2</sub> monocrystal window, 15 is a photo-electron multiplier, 16 is a first dinode deposited with a KCl thin film in 1000 Å thick, 17 is an amplifier connected with an output of the multiplier 15 and 18 is a pulse counter circuit.

The photoemission property of CaF<sub>2</sub> monocrystal window presents a lowpass filter property. That is, the absorption coefficient is abruptly increased at the vicinity of 10 eV wherein the exciton absorption appears, and, in a region exceeding such a cutoff energy, the light transparency is lost, while, in a region below this cutoff energy, the CaF<sub>2</sub> monocrystal window presents almost flat light transparency.

The cutoff energy is caused at the energy level wherein the exciton absorption appears, so that this energy level is varied by the crystal temperature. In practice, this energy level wherein the exciton absorption appears is varied as shown in Figs. 9A and 9B, by the crystal temperature variation from liquid nitrogen temperature (75K) to 375K.

However, even in this case that the crystal temperature is varied, the transparency property in the energy region below the absorption limit is flat, so as to surely realize the variable cutoff lowpass filter.

Next, the photo-detection property of the photo-electron multiplier 15 comprising the first dinode 16 deposited a  $KCl$  thin film with 1000 Å thick will be explained. The first dinode 16 consists of  $CuBe-O$  and the photo-electron absorption property thereof presents finite values in the vicinity of energy level of about 6 eV and, as a result, presents abrupt increase with the increase of photo-energy. This photo-electron absorption property is varied by depositing a  $KCl$  thin film on the surface of the first dinode 16, while the property further abruptly increase together with the increase of photo-energy as shown in Fig. 10. This is because of the reflection of the photoelectron absorption property of  $KCl$  thin film, which consists of an ion crystal being a proper insulator. So that, it results that the  $KCl$  thin film is electrically charged by deriving photo-electrons therefrom. The photoelectron absorption is reduced by depositing too thick  $KCl$  thin film, and is reduced also by depositing too thin  $KCl$  thin film because of reduced contribution thereof, so that it is required to select the most suitable thickness thereof.

When the photo-electron absorption is measured as the increase of thickness of  $KCl$  thin film, it appears that this absorption is almost simply increased until the vicinity of 1000 Å thickness as shown in Fig. 10, and represents the tendency of saturation with further increase of thickness. According to further detailed observation of film thickness dependency of the photo-electron absorption, it appears that the absorption at the vicinity of 8 eV is reduced at the vicinity of 1000 Å thickness. So that, it is possible to realize such a property that the photo-electron absorption is reduced at the vicinity of 8 eV and is suddenly increased over 9 eV by depositing  $KCl$  thin film of 1000 Å thickness.

The photo-electrons 19 emitted from the first dinode 16 are amplified by about  $10^6$  through plural electrode 20 for secondary electron multiplication and are collected by a collector 21. The intensity of collected electrons is observed by a pulse counter circuit 18 after the amplification through an amplifier 17 as a preamplifier. This property of photo-electron multiplier 15 represents the highpass filter property as to the photo-energy, so that the cutoff energy thereof is defined by the rise-up of the photo-electron absorption of  $KCl$  thin film so as to be at the vicinity of about 9 eV.

According to the combination of  $CaF_2$  monocrystal window 12 and the first dinode 16 of the photo-electron multiplier 15 on which  $KCl$  thin film is deposited, that is, the combination of lowpass and highpass filters, it is possible to realize the bandpass filter, the difference of respective cutoff energies of which filters corresponds to the passband width. However, the practical characteristics does not represent an ideal step function as the filter property but only gradual variations in the vicinities of respective cutoff ener-

gies, so that the obtainable bandpass characteristic represents an asymmetric peak structure on the basis of reflections of respective rise-up properties, as shown in Fig. 11.

The cutoff characteristic of the lowpass filter, which depends on the absorption of exciton, is sharp as to the good  $CaF_2$  monocrystal window, while the cutoff characteristic of the highpass filter, which is formed of photo-electron absorption property reflecting the interband transition of  $KCl$  thin film, is comparatively gradual. So that, it is required for narrowing the half value width of the bandpass filter to improve the characteristics of the aforesaid highpass filter. Accordingly, the  $LiF$  monocrystal window 7 deposited with  $KCl$  thin film has entered on the stage.

The transmission property of  $KCl$  thin film represents sharp exciton absorption at the vicinity of 9.5 eV, the energy level of which is somewhat lower than the cutoff of low pass filter and corresponds to the cutoff of highpass filter as shown in Fig. 12.

An improved highpass filter can be realized by combining the  $KCl$  thin film with the first dinode 16 of the aforesaid photo-electron multiplier 15. On the other hand,  $LiF$  monocrystal window 7 is transparent below the vicinity of 11 eV and hence can be used as the substrate for depositing  $KCl$  thin film. Accordingly, a bandpass filter property having central energy 9.9 eV and half value width 0.37 eV as shown in Fig. 13 can be realized by combining these three elements.

$CaF_2$  monocrystal window 12 represents almost ideal lowpass filter property, the cutoff of which is defined by the crystal temperature. When  $CaF_2$  monocrystal window 12 is refrigerated toward low temperature of 74 K, the cutoff energy is shifted toward high energy side, while, when it is heated at high temperature, the cutoff energy is shifted toward low energy side, as it is apparent from Figs. 9A and 9B. Accordingly, the property of bandpass filter represents the variation of property, which corresponds to the variation of high energy cutoff. When  $CaF_2$  monocrystal window 12 is heated at high temperature of about 375 K, the bandwidth is increased, while, when it is refrigerated at low temperature of 47 K, the bandwidth is reduced, as shown in Fig. 14. In addition to the variation of bandwidth, the variation of central energy level is also caused. However, the usage for measuring inverse photoemission spectroscopy can be made possible by the calibration as a function of temperature.

The deterioration of measurement sensitivity is unavoidably caused by the measurement with high resolution, so that much more time than that with usual resolution is required. In the practical measurement, although the measurement with high resolution is preferable, it is required to raise the sensitivity at a certain sacrifice of the resolution in relation to measurement time duration, and hence the bandwidth ad-

justable photo-detector 6 according to the present invention becomes useful. This photo-detector 6 is made applicable by the previous calibration. This means that a novel property can be obtained by additionally providing a temperature adjustable structure such as a thermo-couple 10 and a heater 11 as shown in Fig. 3 in the same structure as the photo-detector 6 afforded with high resolution by utilizing a window deposited with  $KCl$  thin film.

The same property can be theoretically obtained by directly depositing  $KCl$  thin film on the monocrystal window 12 also. However, under the condition such as the temperature adjustable structure is additionally provided so as to be heated, the possibility in that the reaction between  $KCl$  thin film and  $CaF_2$  monocrystal window causes trouble is high. So that it is preferable to dare to provide  $LiF$  monocrystal window 7 for the substrate of  $KCl$  thin film.

According to the present invention, the bandwidth of the bandpass filter used for the photo-detector can be continuously varied from conventional bandwidth 0.35 eV to narrow bandwidth 0.2 eV only by a simple method of heating the crystal of window in the bandpass filter. On the contrary, the bandwidth can be widened by the refrigeration, so that particularly widened bandwidth of about 0.9 eV can be attained at liquid nitrogen temperature. The wider the bandwidth is, the higher the detection sensitivity is, while the sensitivity is reduced with the narrow bandwidth. The case that all materials should be measured with high resolution and long time expense is rare, while particular materials, for instance organic materials and materials having unstable surfaces should be measured in time duration being as short as possible. Furthermore, there is a certain case that the whole of the same sample is measured with low resolution and only a part thereof should be measured with high resolution. However, the photo-detector according to the present invention is efficient, because the resolution of the detector can be optionally set, although setting range is restricted. The present invention has an industrial merit such that the measurement which conventionally necessitates plural apparatus in the prior art can be effected only by one apparatus according to the present invention.

In the bandpass filter type photo-detector for inverse photoemission spectroscopy of the present invention,  $CaF_2$  monocrystal window is used for high cut filter, while for low cut filter there is used the photo-electron multiplier having a sufficient sensitivity in an energy region exceeding that of vacuum ultra-violet ray. In addition to this fundamental arrangement, for improving the performance thereof, the low energy side performance of the bandpass filter is improved by depositing  $KCl$  thin film on  $LiF$  monocrystal window 7 and  $CaF_2$  monocrystal window 12 in the light transmission region, so as to utilize the absorption property inherent to  $KCl$  thin film. Furthermore,

a sensitivity raising material, that is, usually  $KCl$  thin film is deposited on the photoemissive surface of the photo-electron multiplier. The present invention is featured in that, in view of the temperature dependency of light absorption property of  $CaF_2$  monocrystal window and  $KCl$  thin film, the optionally setting of passband width can be realized together with the improvement of bandpass width and sensitivity.

As to the light absorption property of  $KCl$  thin film, as shown in Fig. 5, the absorption in the vicinity of 9.5 eV at low temperature is sharply increased and the absorption in the vicinity of 9.8 eV in bandpass region is reduced, so as to facilitate the light transmission. According to the increase of absorption at low temperature, the same absorption can be obtained through more thin film. For instance, it is possible to reduce from the film thickness of necessitating 150 Å at room temperature (in the prior art) into the order of 100 Å according to the present invention, and hence to facilitate the light transmission within the bandpass region.

The temperature dependency of cutoff energy of  $CaF_2$  monocrystal window is shifted toward low energy side at high temperature, while shifted toward high energy side at low temperature. The sharpness of absorption and the variation of transmissibility in transmissible region are negligibly small. As it is apparent from Fig. 7, the bandwidth can be optionally set by the temperature control of  $CaF_2$  monocrystal window, so as to facilitate the aimed measurement.

This bandwidth adjustable structure can be applied also on the bandpass filter type photo-detector employing other than  $CaF_2$  monocrystal window, that is, anyone selected among  $SrF_2$ ,  $MgF_2$  and  $LiF$  monocrystal windows as high cut filter.

Of course, although the various elements of the two monocrystal windows and the three thin film coatings advantageously work together in the illustrated embodiment, it is possible to use them separately or in sub-combination where their individual improvements are wanted.

Further, it is possible to practice the invention by replacing the substances mentioned above with others having the same optical characteristic.

## Claims

1. A passband-adjustable photo-detector for inverse photoemission spectroscopy, in which an electron beam (2) from an electron gun (1) is applied onto a sample (3) and light (4) reflected therefrom is converged into a photo-electron multiplier (6), so as to effect photo-detection, said photo-detector (2) comprising, a photoelectron multiplier (16), an adjustable high cut optical filter (12), a photo-electric multiplier (15), means for providing a low cut optical characteristic and con-

trol means (8-11) for controlling the high cut optical filter characteristic to control the passband.

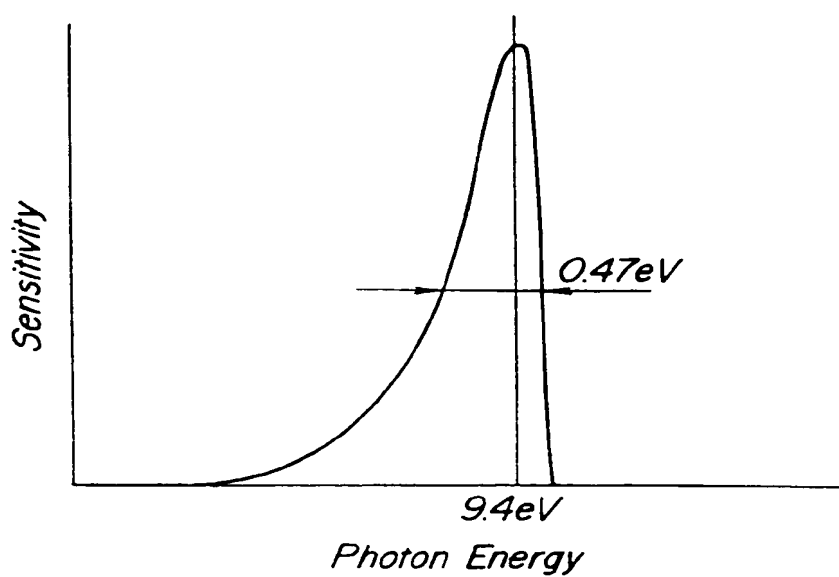
2. A passband-adjustable photo-detector according to claim 1, wherein the adjustable high cut optical filter (12) has a temperature dependent high cut optical filter characteristic, said control means (8-11) comprising means for controlling the temperature of the filter (12). 5
3. A passband-adjustable photo-detector according to claim 2, wherein the temperature is controllable from about liquid nitrogen temperature to a temperature of the order of 150°C. 10
4. A passband-adjustable photo-detector according to claim 2 or 3, wherein the adjustable high cut optical filter (12) is a metal fluoride monocrystal window. 15
5. A passband-adjustable photo-detector according to claim 4, wherein the metal is an alkali or alkali earth metal, e.g. SrF<sub>2</sub>, MgF<sub>2</sub> or LiF, preferably of CaF<sub>2</sub>. 20
6. A passband-adjustable photo-detector according to claim 1, 2, 3, 4 or 5, wherein the photoelectric multiplier (15) has a KCL thin film deposited thereon as the means to provide the low cut characteristic. 25
7. A passband-adjustable photo-detector according to any one of the preceding claims, wherein the high cut optical filter (12) has a KCL film deposited thereon. 30
8. A passband-adjustable photo-detector according to any one of the preceding claims, further comprising a second optical filter formed by a LiF monocrystal window (7) carrying a KCL film thereon. 35
9. A passband-adjustable photo-detector according to any one of the preceding claims, wherein an output of said photo-electron multiplier is connected with a pulse counter circuit through an amplifier, so as to measure any one of: the light absorption property, the window transmissibility and the sensitivity as a bandpass filter for inverse photoemission spectroscopy. 40

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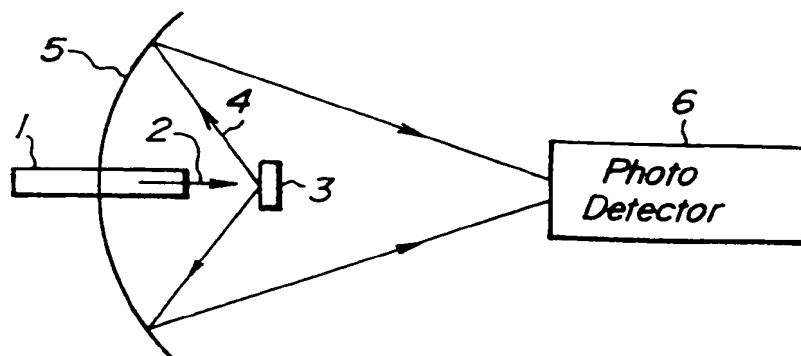
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**FIG. 1**

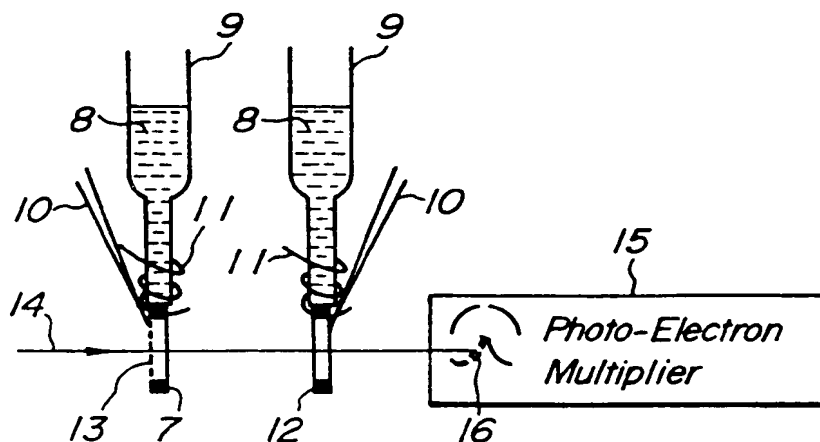


**FIG. 2**

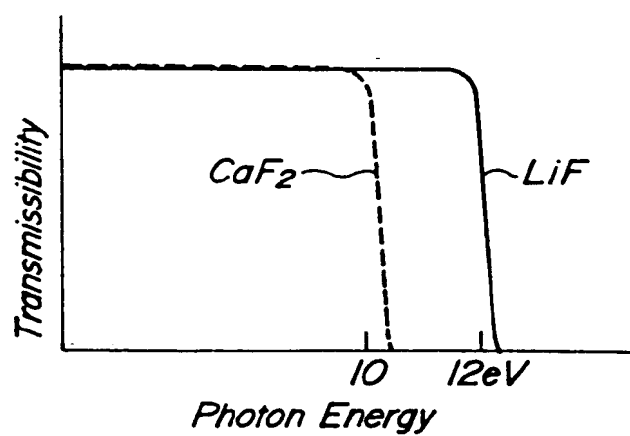




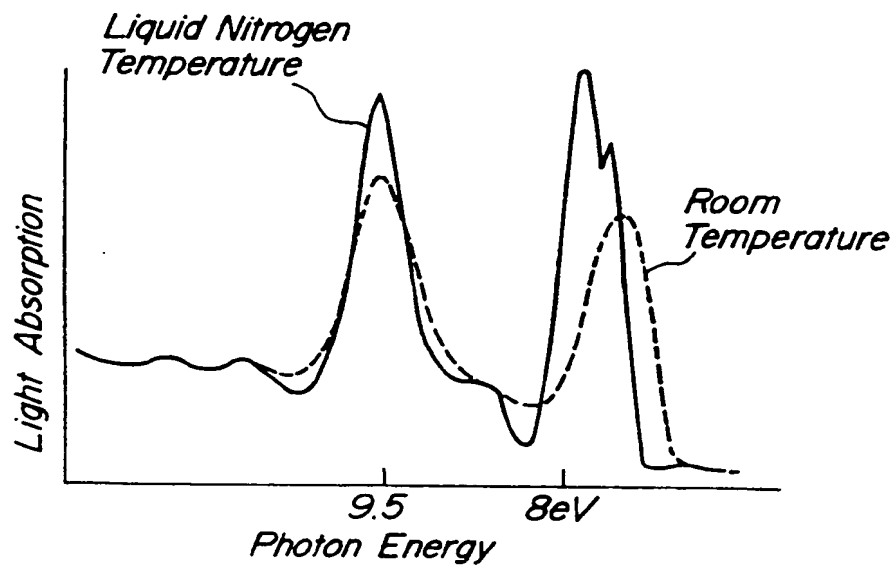
**FIG. 3**



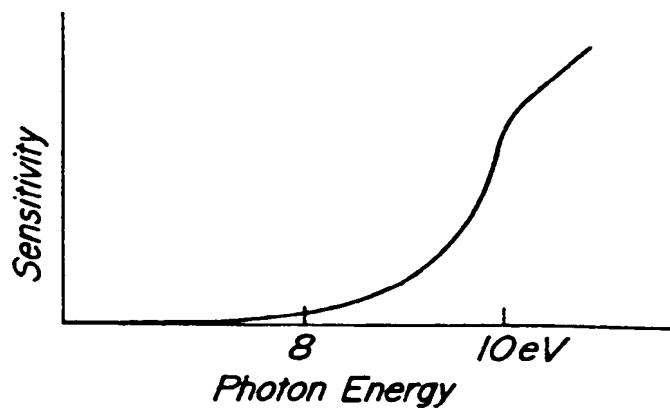
**FIG. 4**



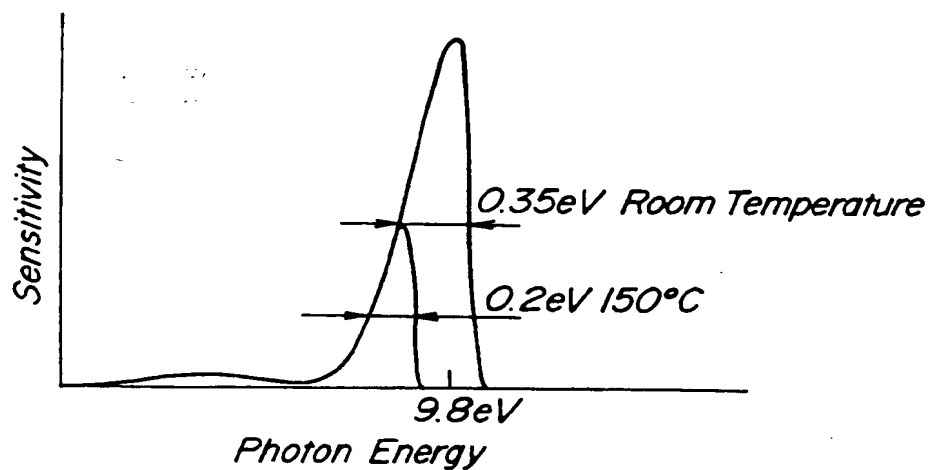
**FIG. 5**



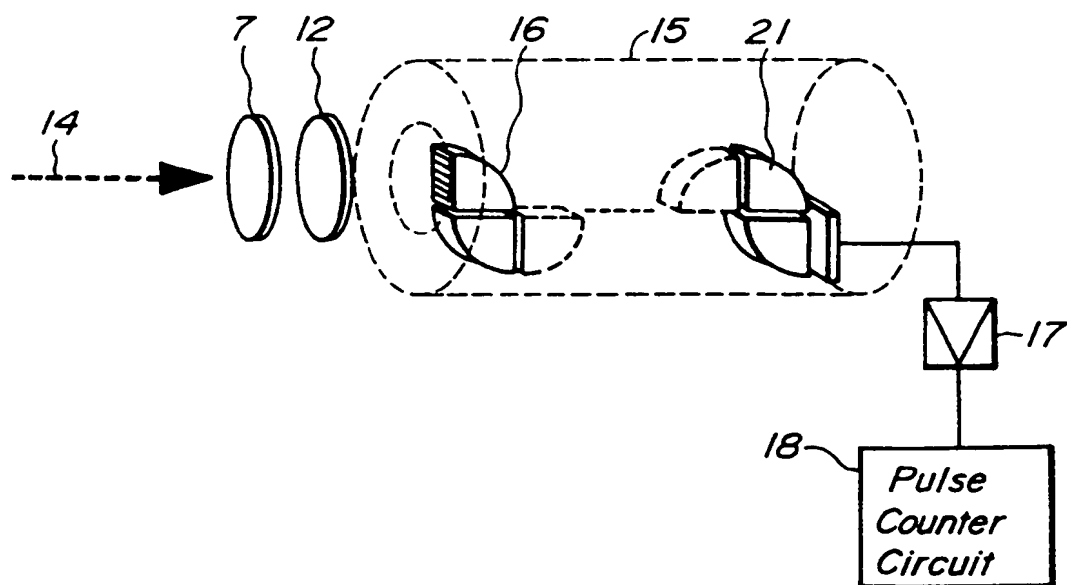
**FIG. 6**



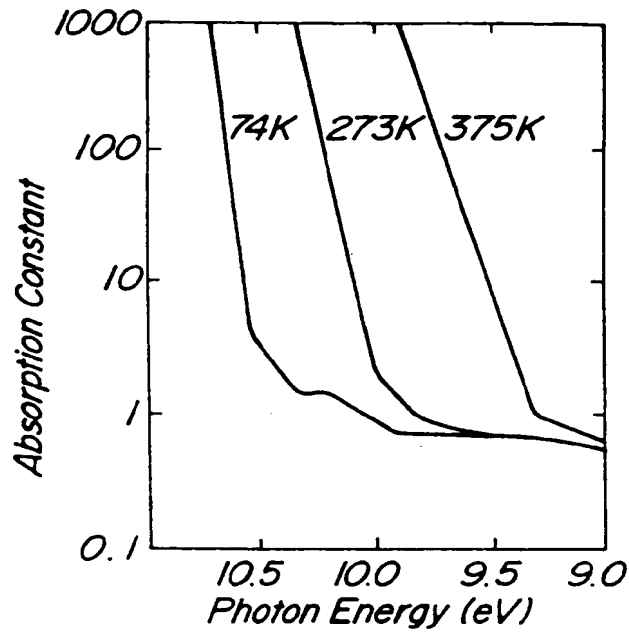
**FIG. 7**



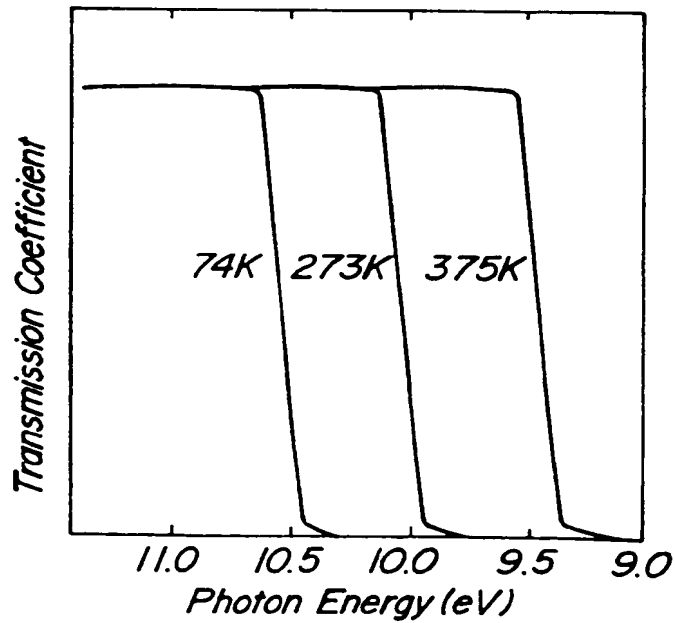
**FIG. 8**



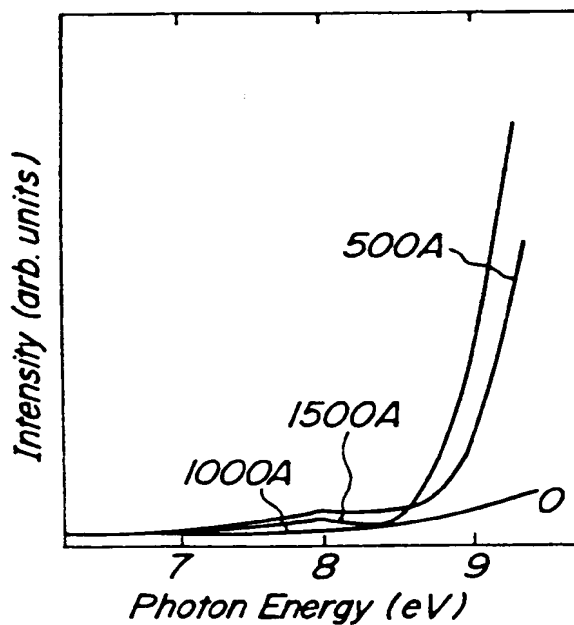
**FIG. 9A**



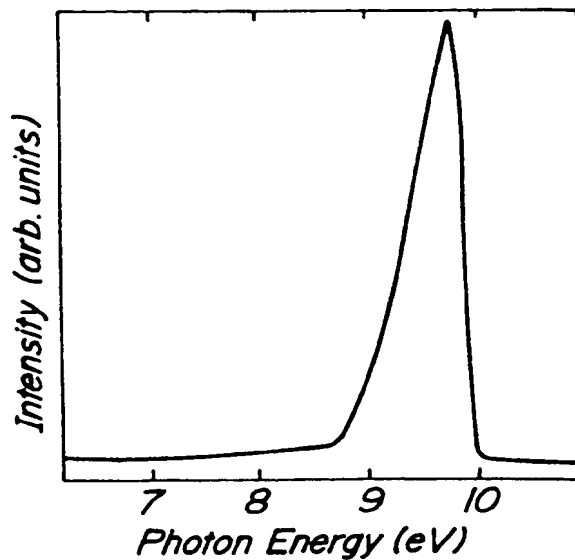
**FIG. 9B**



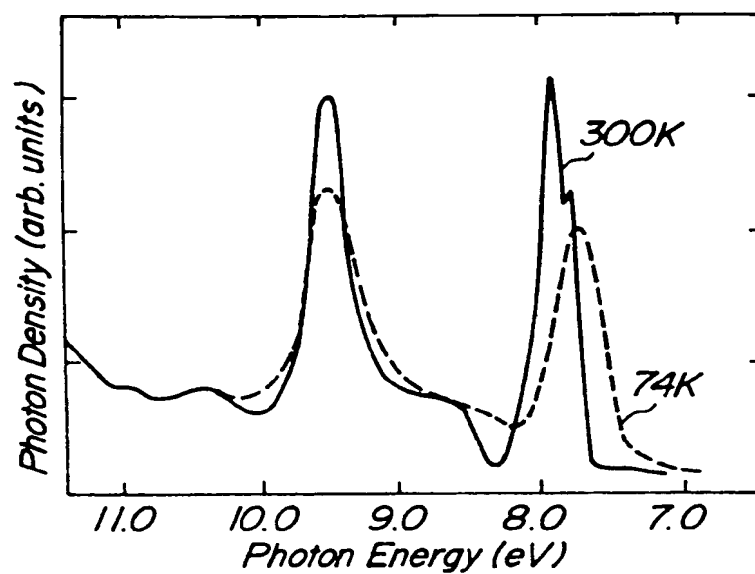
**FIG. 10**



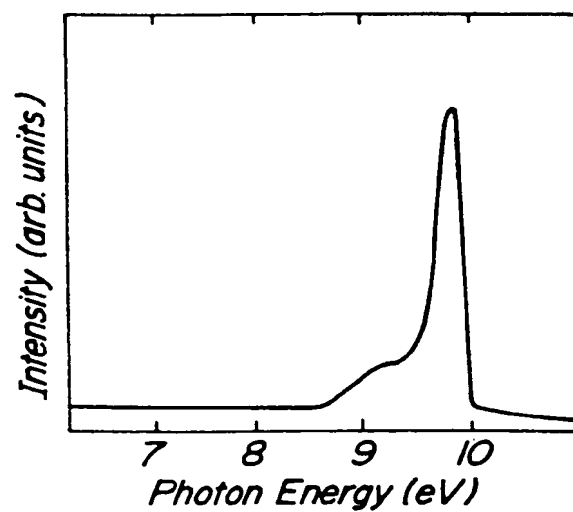
**FIG. 11**



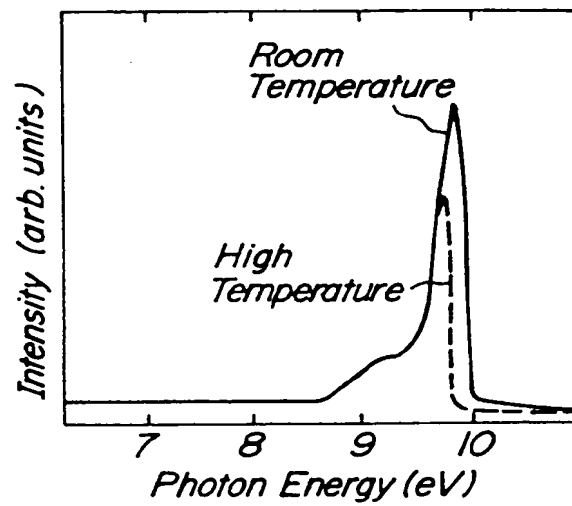
**FIG. 12**



**FIG. 13**



**FIG. 14**





European Patent  
Office

# EUROPEAN SEARCH REPORT

Application Number  
EP 95 30 1781

| DOCUMENTS CONSIDERED TO BE RELEVANT  |   |   |  |
|--|---|---|--|
| Category   | Citation of document with indication, where appropriate, of relevant passages   | Relevant to claim                               | CLASSIFICATION OF THE APPLICATION (Int.Cl.6) |
| X  | EP-A-0 475 305 (SHIMADZU)<br>* column 2, line 49 - column 3, line 10 *<br>* column 5, line 20 - line 38 *<br>* column 7, line 31 - column 8, line 3 *<br>* figures 1,7 *<br>--- | 1,2,4,5,9                                       | G01N23/225                                   |
| A  | EP-A-0 562 874 (HIROSHIMA UNIVERSITY)<br>* claims; figures *<br>-----   | 1-9   |  |
|  |   |   | TECHNICAL FIELDS SEARCHED (Int.Cl.6)         |
|  |   |   | H01J<br>G01N                                 |
| The present search report has been drawn up for all claims   |   |   |  |
| Place of search<br>THE HAGUE   |   | Date of completion of the search<br>4 July 1995 | Examiner<br>Krametz, E                       |
| CATEGORY OF CITED DOCUMENTS<br>X : particularly relevant if taken alone<br>Y : particularly relevant if combined with another document of the same category<br>A : technological background<br>O : non-written disclosure<br>P : intermediate document<br>T : theory or principle underlying the invention<br>E : earlier patent document, but published on, or after the filing date<br>D : document cited in the application<br>L : document cited for other reasons<br>& : member of the same patent family, corresponding document |   |   |  |

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